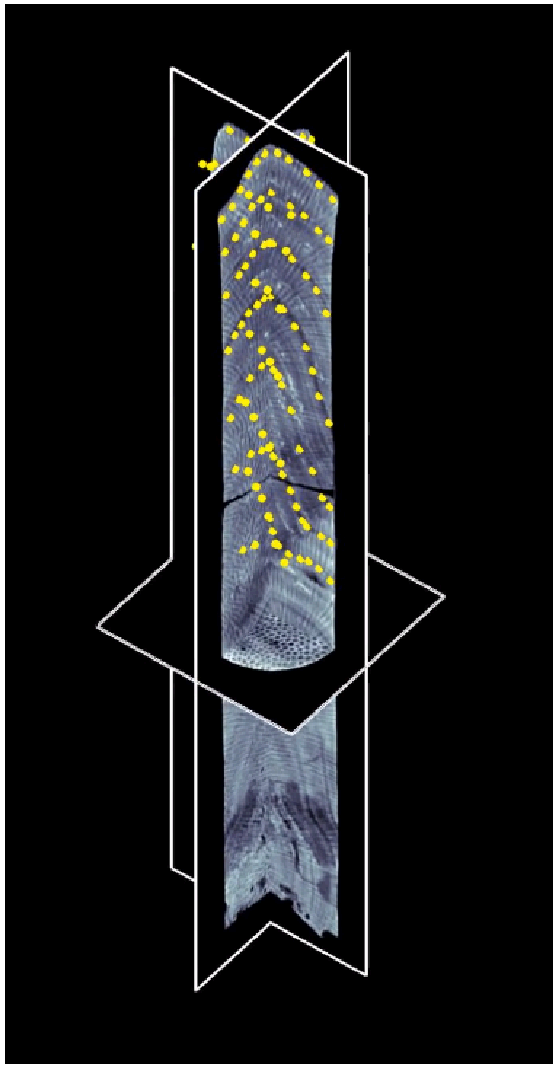


CoralCT Undergraduate Lesson Plan

By: The Sclerochronology Lab at Tulane University

Quick Links:

- CoralCT User Guide
- CoralCT Video Tutorials

For questions, contact us at sclerolab@gmail.com

Background

Coral reefs are critical marine ecosystems that provide habitat for numerous animals, support fisheries, and protect the coast from storms. However, corals are struggling due to environmental stressors such as global warming and pollution, causing many to become unhealthy and degrade. Therefore, it's important to assess how healthy coral is and understand how their growth is changing over time due to these stressors so scientists can take action to prevent further damage.

One way coral health can be assessed is through the study of their skeleton. Coral skeletons record information about growth and environmental changes over time in the form of annual density bands. These bands, similarly to tree rings, record how much the coral grows, or calcifies, over the course of one year. Changes in calcification rates offer insights into how environmental factors, such as ocean temperatures, affect coral growth and health.

To study these skeletons, scientists drill into coral skeletons and remove portions called cores. They can CT scan or X-ray the cores to better visualize and analyze these bands. CoralCT is a software tool designed to archive and analyze these X-rays and CT scans, some showing centuries of coral growth. These scans have been uploaded by scientists and organizations from around the world.

Important Vocabulary:

1. **Coral:** A marine animal that lives in colonies and builds hard, rock-like skeletons that form coral reefs.
2. **Calcification:** The process by which corals absorb calcium carbonate from seawater to build their skeletons.
3. **Skeleton:** The hard, calcium-based structure that corals build and live on and forms the framework of coral reefs.
4. **Calcification rate**: How fast the coral is growing. If it's increasing, the coral is growing more. If it's decreasing, the coral is growing less.
5. **Core:** A cylinder-shaped sample that is taken from massive (dome-shaped) coral skeletons and used to study coral health.
6. **Annual Density Bands:** Visible layers in a coral's skeleton, like tree rings, that show how much the coral grew in a single year.
7. **CT Scan/X-ray:** Imaging techniques that help to see the annual density bands of coral cores more clearly, since the bands are often hard to see when looking at the physical core.
8. **Global Warming:** The long-term rise in Earth's average temperature, mainly caused by the trapping of heat in Earth's atmosphere due to greenhouse gases. Greenhouse gases include carbon dioxide (CO_2) and methane. A similar example is when you get into a car in the summer, it's hotter inside the car than outside.
9. **Climate Change:** The long-term change in Earth's average weather patterns, such as precipitation, air temperature, storms, etc., mainly caused by global warming.

10. **Ocean Acidification:** A lowering of the ocean's pH level due to carbon dioxide (CO_2) from the atmosphere dissolving in the water. The dissolved CO_2 causes less carbonate in the water, which corals need to build their calcium carbonate skeletons.

Lesson Plan

Lesson Title: Analyzing Coral Calcification Rates Using CoralCT

- **Audience**
    - Undergraduate students with some level of marine science background.
- **Purpose of Activity**
    - These activities are designed to provide undergraduate students with experience using the CoralCT software to analyze coral core imagery, interpret calcification rates, and formulate hypotheses about environmental influences on coral reef ecosystems. This exercise emphasizes scientific reasoning, data analysis, and the application of marine biology and environmental science principles.
- **Learning Objectives**
    - Students will use the CoralCT application to understand the field of sclerochronology and its significance in coral reef science.
    - Students will analyze X-rays and CT scans of coral skeletal cores by mapping annual density bands. They will use scientific reasoning and their knowledge of coral biology to predict growth rates over time. Students will process and analyze their data to observe calcification trends.
    - Students will use their data analysis skills to form and explain their scientific conclusions.
- **Materials**
    - Personal laptops with CoralCT pre-installed and accounts set up (students should complete this outside class. Please refer to the CoralCT user guide for download instructions: User Guide)
    - Excel (or equivalent spreadsheet software) for data visualization
    - List of recommended coral core samples to use for this lesson (see below)
    - Worksheet (see below)
- **Activities**
    - **Activity 1: Core Selection and Initial Analysis**
        - Each student will select a core from the recommended list below.
        - Students will then map the bands of the core to analyze calcification rates. For more details on how to map the bands, please show the following video tutorials to the class or refer to the steps in the User Guide.
        - Students will **predict** the relationship between time (years) and calcification rates (e.g., increasing, decreasing, or stable) and provide a biological or environmental rationale for their prediction.
            - This analysis can be done more formally on the worksheet we've created, or this can be done through classroom discussion.
        - Once they process their core, students will download their calcification rate data using the "Access Data" page in the CoralCT application. Their data will be downloaded into their local working directory on their computer (see User Guide for further instructions). They will use these data to create a line graph in Excel with time (years/band numbers) on the x-axis and calcification rate on the y-axis. *Ensure*

students select the calcification rate (Column G) and not the calcification rate standard deviation (Column H).

        - For better visualization, have students add a trendline to the graph, which will show how the calcification rate changed over time. *A reminder that band 1 on the x-axis represents the top of the core and the year it was collected (i.e., the closest time to present day).*
        - Students will compare their previous predictions to the results of their data. They will discuss why their predictions were correct or incorrect and attempt to explain the results of their data conceptually, incorporating biological reasoning.
    - **Activity 2: Regional Comparison**
        - Students will select a second core that is the **same genus** (in parentheses and italicized beside the core ID on the list) as their first core, but **from a different region** in the provided list.
        - Students will map the bands of the second core and process it. They will then download these data using the Access Data page in CoralCT. They will create a second line graph for this core as well, with time (years) on the x-axis and calcification rate on the y-axis.
        - Students will explain how their two graphs compare and contrast.
        - Students will then research the two regions and delve deeper into biological and environmental explanations, such as regional temperature variations, nutrient levels, or local stressors. This will require them to do outside research on the sites where the cores were collected, looking into historical weather events and human presence.
    - **Activity 3: Discussion or Submission**
        - Students participate in a class discussion to share findings and explore broader patterns observed in the activity. Discussions may focus on biological processes, regional environmental factors, and implications for coral reef conservation.
        - Alternatively, students may submit written responses for all activities using the worksheet, including their line graphs, predictions, and explanations.
- **Recommendations:**
    - To keep the students organized, use our example worksheet for them to follow, which includes spaces for them to input their graphs and explanations for their predictions and findings. This can be accessed below and used on their computers or printed out (however, they will need to draw their graphs if printed).
    - Use the list of recommended cores (see below) for these activities rather than choosing a core at random, as some cores have a large file size and will take a long time to open on the computers, or some have less distinct banding patterns and will be difficult for the students to map.
- **References and Supplementary Materials**
    - Our published CoralCT manuscript for background scientific information (can be accessed here)
    - CoralCT User Guide and video tutorials (available at www.coralct.org and linked above)
    - CoralCT Community Slack (join here)

    - Worksheets (see below)
- **Acknowledgments/Authors**
    - This activity was developed by the Sclerochronology Lab at Tulane University to promote STEM education and awareness of coral reef science.

List of Recommended Cores

- **Region: Red Sea, Subregion: Central Red Sea**
    - K01 (*Porites*)
        - This core is longer, with approximately 51 annual density bands. Its bands can be easily distinguished throughout the entire core. Analyses can be expected to show a very slight decline in calcification over time. Its file size is 188 MB.
    - K03 (*Porites*)
        - This core is medium length with approximately 44 bands and should show a distinct decline in calcification rate over time. Its bands are distinct throughout most of the core, with some areas where the bands are not as straight. Its file size is 118 MB.
    - K12 (*Porites*)
        - This core is very short in length, with approximately 9 bands total. The calcification rate stays completely stable over time. This core would be beneficial to practice mapping bands for its small size and distinct bands rather than conducting analyses. It is 30 MB in file size.
    - K15 (*Porites*)
        - The bands of this core are very distinct all the way through. This is a longer core with approximately 50 bands. Analyses should show a slight decline in calcification rate over time. It is 210 MB in file size.
    - K16 (*Porites*)
        - This core is longer, with approximately 48 bands, and has very distinct bands throughout the entire core. It can be expected to show an increase in calcification rate over time. It is 204 MB in file size.
    - K17 (*Porites*)
        - This core is medium length and has distinct bands throughout, although the bands are not completely straight. It has approximately 30 bands and should show a slight decline in calcification over time. It is 90 MB in file size.
    - K19 (*Porites*)
        - This is a longer core with very distinct bands throughout the entire core. It has approximately 53 bands and is expected to show a decline in calcification over time. It is 216 MB in file size.
    - NRS08 (*Porites*)

        - This core is shorter and has slightly less distinct banding. This will be better for a higher challenge for students to map bands. It is 79 MB in file size.
    - NRS09 (*Porites*)
        - This core is a medium length with approximately 19 bands. It has distinct banding throughout and should show an increase in calcification rate over time. It is 94 MB in file size.
    - NRS10 (*Porites*)
        - This core is short in length, with approximately 25 bands that are very distinct and easy to map. It is expected to show a slight decline in calcification rate over time. It is 83 MB in file size.
- **Region: Red Sea, Subregion: Northern Red Sea**
    - NRS13 (*Porites*)
        - This is a shorter core with very distinct bands that are closer together. It has approximately 36 bands and should show a clear decline in calcification rate over time. It is 79 MB in file size.
- **Region: Red Sea, Subregion: Southern Red Sea**
    - F02 (*Porites*)
        - This core is medium length with bands very close together. The bands do become less straight at the bottom of the core. It has approximately 30 bands, and analyses should be expected to show a clear decline in calcification over time. It is 68 MB in file size.
    - F14 (*Porites*)
        - This core is longer, and the bands are distinct but not as straight and slightly harder to follow. This would be a good core to assign after the student(s) have had practice mapping bands. It has approximately 43 bands and should show a decline in calcification rate over time. It is 118 MB in file size.
    - F28 (*Porites*)
        - This core is very short (approximately 15 bands) and has very distinct bands. This core would be good for students to practice mapping bands. It is 48 MB in file size.
    - F46 (*Porites*)
        - This is a very long core with approximately 88 bands. The bands are distinct throughout most of the core, with some areas of less distinction, especially at the bottom. It should show a clear decline in calcification rate over time. It is 291 MB in file size.
- **Region: Taiwan, Subregion: Dongsha Atoll**
    - T752 (*Porites*)
        - This core is shorter and has distinct banding. It has approximately 10 bands and shows a distinct decline in calcification rate. It is 307 MB in file size.
    - T769 (*Porites*)
        - This core has very distinct banding and is medium length, with approximately 21 bands, and is expected to show a clear decline in calcification rate over time. It is 349 MB in file size.

    - T771 (*Porites*)
        - This core is shorter, with approximately 20 bands, and is expected to show a slight decline in calcification rate over time. The bands are also distinct, and the core is 305 MB in file size.
    - T886 (*Porites*)
        - This core is shorter in length and has slightly less distinct banding in parts of the core. It has approximately 14 bands and shows a clear increase in calcification rate over time. It is 324 MB in file size.
    - T892 (*Porites*)
        - This core is a shorter length and has distinct banding. It has approximately 14 bands and should display an increase in calcification rate over time. It is 339 MB in file size.
- **Region: Taiwan, Subregion: Green Island**
    - T703 (*Porites*)
        - This is a short core with very distinct bands and is good for practicing band mapping. It has approximately 14 bands and should show an increase in calcification rate over time. It is 226 MB in file size.
    - T708 (*Porites*)
        - This is a long core with very distinct banding. It has approximately 31 bands and should display a decline in calcification over time. It is 380 MB in file size.

Worksheet

CoralCT Activity

Name: ____

Directions: You should already have CoralCT downloaded on your computer and have a general understanding of how the application works. For more information, please review our User Guide and video tutorials at www.coralct.org.

Important terms to know:

Coral: A marine animal that lives in colonies and builds hard, rock-like skeletons that form coral reefs.

Global Warming: The long-term rise in Earth's average temperature.

Core: A cylinder-shaped sample that is taken from massive (dome-shaped) coral skeletons and used to study coral health.

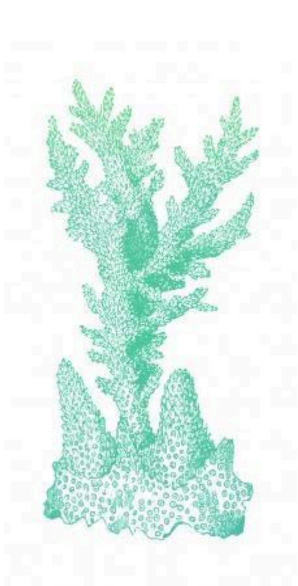
Skeleton: The hard, calcium-based structure that corals build and live on and forms the framework of coral reefs.

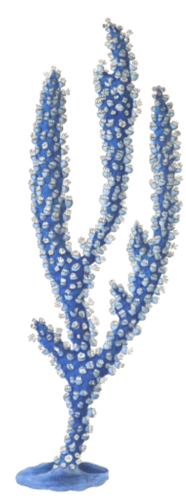
Calcification: The process by which corals absorb calcium from seawater to build their skeletons.

Calcification rate: How fast the coral is growing. If it's increasing, the coral is growing more. If it's decreasing, the coral is growing less.

Annual Density Bands: Visible layers in a coral's skeleton, like tree rings, that show how much the coral grew in a single year.

CT Scan/X-ray: Imaging tools that help to see the annual density bands of coral cores more clearly, since the bands are often hard to see when looking at the physical core.





Core 1 ID: ______________________

Region: ________________________

Subregion: _____________________

Username: _____________________

1. How difficult was it to map the bands of this core? Were there any areas of the core where you were unsure of the banding?

2. What patterns did you notice about the banding throughout the core? Was the spacing the same throughout? Were there areas of the core where the spacing between bands changed?

3. Based on your answer above, predict the coral's growth rate. Do you think the growth rate decreased (i.e., the spacing between bands got smaller as you moved towards the top of the core)? Do you think the growth rate increased? Is there no clear pattern?

4. Process your core and go to the Access Data page from the CoralCT main page. Select the region and subregion of your core, then choose the core you processed and select your username to download the growth rate data you created. Once it's downloaded, it will be located in your local working directory on your computer. Open these data in Excel (or another spreadsheet platform) and find the calcification column (Column G) (*make sure not to select the calcification rate standard deviation in column H*). Create a line graph using these data with time (number of bands) on the x-axis and calcification rate on the y-axis. Add a trendline to the graph. Is the calcification rate increasing, decreasing, or stable? A reminder that band 1 on the x-axis represents the top of the core.

5. Why do you think the above trend is occurring? Use information about the coral genus, the region your core is located and other scientific reasons based on coral science to explain your answer. This will require outside research.

Core 2 ID: ______________________

Region: ________________________

Subregion: _____________________

6. How difficult was it to map the bands of this core? Were there any areas of the core where you were unsure where the bands were?

7. What patterns did you notice between the bands throughout the core? Was the spacing the same throughout? Were there areas of the core where the space between each band was smaller or larger?

8. Based on your answer above, predict the coral’s growth rate. Do you think it decreased (i.e., the spacing between bands got smaller as you moved towards the top of the core)? Or do you think it increased? Or is it indistinguishable?

9. Process your core and go to the Access Data page on the CoralCT main page. Enter the region and subregion of your core, then choose your core and find your username to download the growth rate data. Once it's downloaded, open these data on your computer in Excel (or another spreadsheet platform) and find the calcification column (make sure not to select the calcification rate standard deviation column). Create a line graph using these data with time on the x-axis (bands/years) and calcification rate on the y-axis. Add a trendline to the graph. Is the calcification rate increasing, decreasing, or stable?

10. Why do you think the above trend is occurring? Use information about the coral genus, the region your core is located and other scientific reasons based on coral science to explain your answer.

11. Compare your two cores. How are their growth rates similar? How are they different? If these cores are from the same genus, what could cause these differences?